CONTINUOUS AND PERIODIC SORPTION CRYOCOOLERS FOR 10 K AND BELOW*

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SUMMARY

This paper summarizes the current status of sorption cryocooler development for space applications requiring cooling of infrared and submillimeter sensors to 10 K and below. Ground test results and flight test plans for the flight-qualified Brilliant Eyes 10 Kelvin Sorption Cryocooler Experiment (BETSCE), and test results from a small laboratory periodic 10 K sorption cryocooler arc presented. These periodic sorption coolers arc ideal for applications that require only intermittent operation at 10 K, with quick cooldown capability (under 2 minutes).

For applications that require continuous cooling, several design variations for high-efficiency lightweight sorption cooler systems arc described, and performance predictions and important design challenges arc discussed, Ground test results from a continuous 25 K cooler planned for use in a long duration airborne balloon experiment arc also presented. This 25 K cooler can be used as an upper stage for a continuous 10 K sorption cooler. Similar] y, the potential benefits of using a 10 K sorption cooler as an upper stage for a 4 K cooler arc also described.

All of the 10 K cooling stages use hydrogen as the refrigerant fluid. Sorbent beds containing metal hydride powders arc sequent i all y heated to thermall y compress the hydrogen. The compressed hydrogen is then expanded and liquefied in a Joule-ThonNon refrigeration cycle to produce the desired cooling effect. The low pressure hydrogen exhaust gas is then chemically absorbed by a cooled sorbent bed. ZrNi hydride sorbent beds arc used to provide the low vacuum pressure ($< 2.6 \times 10^{-4}$ M Pa) needed to solidify and cool hydrogen to < 10 K. $LaNi_{4.8}Sn_{0.2}$ hydride sorbent beds arc used to achieve the final compression to typical pressures of about 10 MPa. Thermally cycling the sorbent beds between about 290 and 550 K produces an overall compression ratio of over 10^5, without the use of any moving parts in the compressor.

The status of ongoing reliability physics experiments designed to demonstrate 10 year life capability for these coolers is also summarized. This includes heater and hydride material characterization and life-cycling tests.

in summary, the combination of long-life, negligible vibration, ability to be scaled easily over a wide range of cooling loads, low weight, and high efficiency makes sorpt ion cooling a highly attractive technique for both periodic and continuous cooling of space instrument sensors to 10 K and below. Efficiencies arc significant y greater than for Stirling or Pulse Tube coolers at this temperat arc, and weight/lifct ime ratios arc much lower than for solid hydrogen or liquid helium cryogenic storage systems.

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